dRICH details for YR

15/Apr/2020
PID-YR meeting

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largely based on Alessio del Dotto work

Considerations
(from previous meetings and further discussions)

- For each detector we need models that provide estimation of performance, based on:
  - Semi-analytic parameterization (for fast evaluation)
  - realistic Montecarlo simulation (for detailed assessment)
- Each model shall report all assumptions behind it;
- The comparison of different EIC-spectrometer configurations (or part of them) requires:
  - consistent underlying assumptions of the different detector models,
  - similar level of feasibility,
  - equivalent model reliability
- We should consider different scenarios (possibly 2) for each proposed EIC configuration ranging between (they may overlap):
  - **State of the art**: assumptions rely as much as possible on what today can be considered achiveable based on experimental data and literature;
  - **Optimal EIC**: assumptions are "free", likely unavailable today but expected to be reasonably feasible for the EIC era after dedicated R&D
- For each proposed detector, we should list risks/mitigations

dRICH – Software Status

Montecarlo (GEMC/Geant4)

- Cherenkov angle reconstruction by Inverse Raytracing Method (no uncertainty in detector geometry)
- Source code: github.com/EIC-eRD11/dualRICH_inMEIC

Parameterized Model → **Roberto Slides**

PID reconstruction (beta) of MC data

- Event based reconstruction
- Provide confusion/Migration matrix (tested on PYTHIA DIS events)

AI-driven Optimization (original idea by C. Fanelli)

- Use Montacarlo model and an efficient maximization strategy of a figure of merit (e.g. for dRICH: combinations of nσ's in different momentum regions)
- **Flexible tool, can be ported to different detectors and combination of them!**

dRICH - MC External Assumptions

Tracking	
Angular resolution	σ = 0.5 mrad (1 mm over 2 m) – whole momentum range
Impact point resolution	σ = 0.3 mm
Momentum resolution dP/P	+/- few percent negligible effects in Cherenkov angle reconstruction
Magnetic Field	3 Tesla Central Field in JL-MEIC spectrometer
Space Requirement	(based on original spectrometer constraints)
longitudinal length	JLEIC: ≈1.6 m, ePHENIX: ≈1.0 m
transverse radius	JLEIC: ≈2.5 m, ePHENIX: ≈2 m
beam pipe radius	<10 cm
Background	no direct external background only backrground produced by the simulated charged particle: Delta rays, Rayleigh scattering …

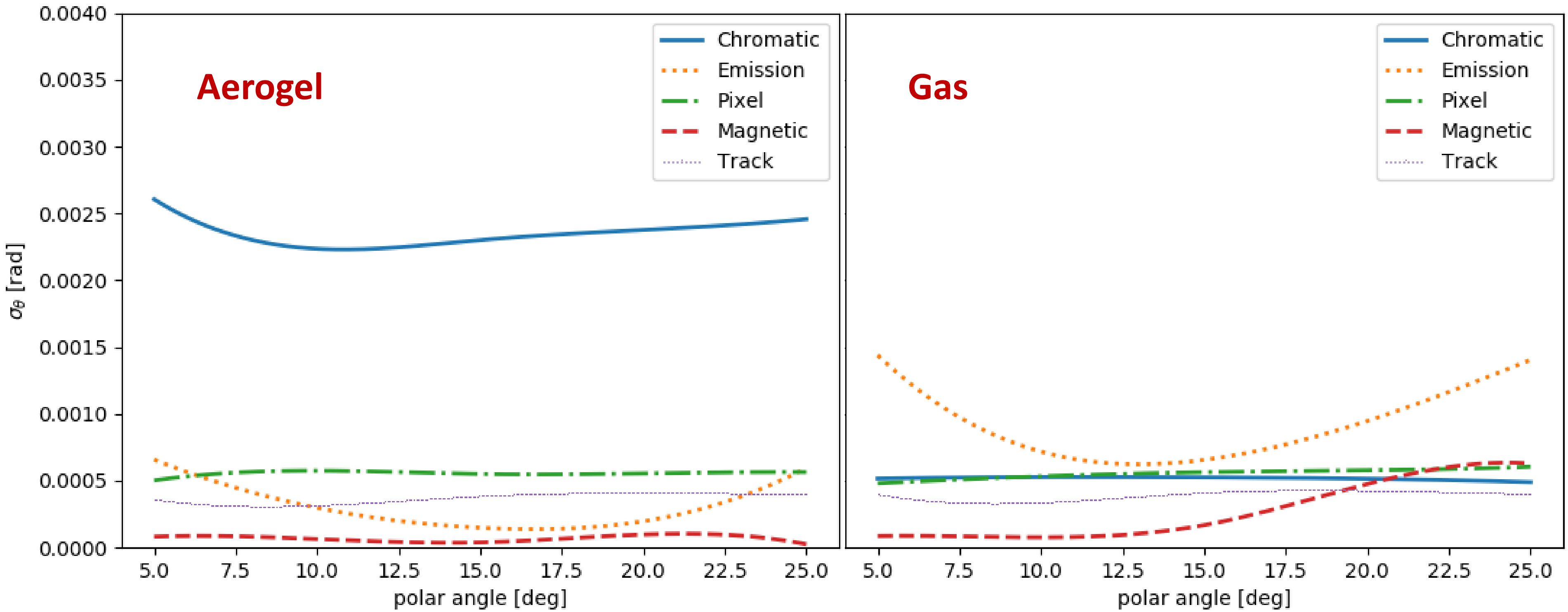
dRICH - MC Internal Assumptions

Aerogel radiator	n=1.02, 4 cm Characteristics scaled from CLAS12/RICH measurements
Gas radiator	n=1.0008, 160/100 cm - C2F6 yield scaled from CF4 data (x0.7); chromaticity from literature (NIMA 354(1995)417); constant absorption length
Mirror	Reflectivity from CLAS12/RICH measurement; Roughness not included
Photon Detector	3 mm pixel size; 200-500 nm MAPMT characteristics from CLAS12 measurements
Vessel	no thickness assumption so far
Background	
Sensor Electronics	Random - spatially uniform on photosensor, poissonian with 30 hits/event mean (assuming 1kHz/pixel dark count x 100 ns) Note: uniform background hits do not influence noticeably the angular resolution; they influence the PID and therefore the migration matrix
Acrylic filter	3.2 mm (from HERMES and LHCb), remove aerogel photons (Rayleigh scattering) below 300 nm impact on ≈1% of signal photons
Particle Generation	All charged particles originate from the vertex and are uniformely distributed in the angular phase space

dRICH MC Cherenkov Angle Resolution

Single Photon Cherenkov Angle Resolution

- Main contributors shown
- Charged particle momentum 30 GeV/c
- Photo sensor surface "optimized" (slightly curved)



dRICH - Pros

1. **>3σ π-K separation in 3 – 50 GeV** whole range in RICH mode (Montecarlo simulation) – as well as large coverage for K-p (and electron) PID
2. **Photon detector out of acceptance** and far from the beam pipe in moderate magnetic field ($\leq$ 1/2 of central zone): less constraints on material budget (e.g. mechanical supports, shielding, cooling); neutron flux is also reduced
3. Expected to be **cheaper and more compact** (also in terms of services) than 2 (or more) detectors solution (sparing on photon detector and related electronics)
4. **Material budget** likely smaller than 2 detector solutions: from CLAS12/RICH-LTCC: $X_0 \approx 1\%$ vessel (no pressurization) + 1% mirror + aerogel, acrylic filter and gas
5. Two dual radiator RICHes already operated (**lesson learned**)
6. Rather **advanced software available**: detailed Montecarlo, parameterization, full PID reconstruction, automated optimization procedure

dRICH - Cons

1. **More demanding PID** respect to single radiator RICH
2. **LHCb dual radiator RICH1 issues**: underestimation of aerogel stability in contact with freon gas?
   large multiplicity and relative large background ?
3. **Aerogel chromatic** performances are critical and need to be well investigated in terms of stability and interference with other gases
4. **R&D on photo sensors** needed (common to other detectors)
5. **Gas Procurement** potential issue due to possible ecological restrictions and costs (common to other detectors)

dRICH Key Hardware Components 1/2

Component	Function	Specs/Requirements	Risk	Mitigation
Mechanics	Support all components and services; keep in position and aligned	Large volume gas and light tightness; alignment of components (1% rad length STP gas)		
Optics (Mirrors)	Focus (expecially for gas) and deflect photons out of particle acceptance and reduce sensor surface	sub-mrad precision reflectivity $\geq$ 90% low material budget (1% rad length from CLAS12/RICH)	Cost could be signficant if very challenging material budget required	Spherical mirrors technology of CLAS12 suitable (carbon fiber and/or glass skin); similar geometry; **Development for cost reduction**
Aerogel Radiator	Cover Low Mom. Range between TOF and Gas	$\geq 3\sigma$ π-K separation up to Gas region (~13 GeV)	**Long term stability performance need to stay "at top"; Procurement: currenly 1 active provider (2 producers, 1 potential)**	Exploit CLAS12/RICH experience and characterization facility Production time: 4 m2/2.5 y **Carry on evaluation of long term stability study Support potential new providers**
Gas Radiator	Cover High Mom. Range above Aerogel	$\geq 3\sigma$ π-K separation up to ~50 GeV and overlap to aerogel	Greenhouse gas: potential procurement and cost issue	**Search and evaluate alternatives**

dRICH Key Hardware Components 2/2

Component	Function	Specs/ Requirements	Risk	Mitigation
Photon Detector	Single photon spatial detection	Magnetic field tolerant and radiation hardness; ~ few mm spatial resolution	MCP-PMT is likely duable, but expensive. Need to find alternatives	LAPPD may represent an alternative. **R&D on SiPM:** a promising, quicky improving, wordwide pursued, and cheap technology.
Electronics	Amplify and shape single photon analog signal, convert to digital, transfer to DAQ nodes	Low noise Time res. ~ 0.5 ns μs signal latency; High density	No major risk but need to be tailored to photon sensors	MAROC3 based readout available for prototyping; final choice will depend on sensor. **ASIC development for optimised streaming readout (discrimination vs sampling)**